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DTC PROJECT NO. 8-CO-160-UXO-021
REPORT NO. ATC-8966

STANDARDIZED

UXO TECHNOLOGY DEMONSTRATION SITE

BLIND GRID SCORING RECORD NO. 397

SITE LOCATION:
U.S. ARMY ABERDEEN PROVING GROUND

DEMONSTRATOR:
NAEVA GEOPHYSICS, INC
P.O. BOX 7325
CHARLOTTESVILLE, VA 22906

TECHNOLOGY TYPE/PLATFORM:
EM61 MKII/TOWED

PREPARED BY:
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ABERDEEN PROVING GROUND, MD 21005-5059

JUNE 2005

Prepared for:
U.S. ARMY ENVIRONMENTAL CENTER
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14. ABSTRACT
This scoring record documents the efforts of NAEVA Geophysics, Inc. to detect and discriminate inert unexploded ordnance (UXO) utilizing the APG Standardized UXO Technology Demonstration Site Blind Grid. The scoring record was coordinated by Larry Overbay and by the Standardized UXO Technology Demonstration Site Scoring Committee. Organizations on the committee include the U.S. Army Corps of Engineers, the Environmental Security Technology Certification Program, the Strategic Environmental Research and Development Program, the Institute for Defense Analysis, the U.S. Army Environmental Center, and the U.S. Army Aberdeen Test Center.

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SECTION 1. GENERAL INFORMATION

1.1 BACKGROUND

Technologies under development for the detection and discrimination of unexploded ordnance (UXO) require testing so that their performance can be characterized. To that end, Standardized Test Sites have been developed at Aberdeen Proving Ground (APG), Maryland and U.S. Army Yuma Proving Ground (YPG), Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in ordnance and clutter. Testing at these sites is independently administered and analyzed by the government for the purposes of characterizing technologies, tracking performance with system development, comparing performance of different systems, and comparing performance in different environments.

The Standardized UXO Technology Demonstration Site Program is a multi-agency program spearheaded by the U.S. Army Environmental Center (AEC). The U.S. Army Aberdeen Test Center (ATC) and the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program (ESTCP), the Strategic Environmental Research and Development Program (SERDP) and the Army Environmental Quality Technology Program (EQT).

1.2 SCORING OBJECTIVES

The objective in the Standardized UXO Technology Demonstration Site Program is to evaluate the detection and discrimination capabilities of a given technology under various field and soil conditions. Inert munitions and clutter items are positioned in various orientations and depths in the ground.

The evaluation objectives are as follows:

a. To determine detection and discrimination effectiveness under realistic scenarios that vary targets, geology, clutter, topography, and vegetation.

b. To determine cost, time, and manpower requirements to operate the technology.

c. To determine demonstrator's ability to analyze survey data in a timely manner and provide prioritized "Target Lists" with associated confidence levels.

d. To provide independent site management to enable the collection of high quality, ground-truth, geo-referenced data for post-demonstration analysis.

1.2.1 Scoring Methodology

a. The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver-operating

characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}), and those that do not correspond to any known item, termed background alarms.

b. The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the blind grid RESPONSE STAGE, the demonstrator provides the scoring committee with a target response from each and every grid square along with a noise level below which target responses are deemed insufficient to warrant further investigation. This list is generated with minimal processing and, since a value is provided for every grid square, will include signals both above and below the system noise level.

c. The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such and to reject clutter. For the blind grid DISCRIMINATION STAGE, the demonstrator provides the scoring committee with the output of the algorithms applied in the discrimination-stage processing for each grid square. The values in this list are prioritized based on the demonstrator's determination that a grid square is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For digital signal processing, priority ranking is based on algorithm output. For other discrimination approaches, priority ranking is based on human (subjective) judgment. The demonstrator also specifies the threshold in the prioritized ranking that provides optimum performance, (i.e. that is expected to retain all detected ordnance and rejects the maximum amount of clutter).

d. The demonstrator is also scored on EFFICIENCY and REJECTION RATIO, which measures the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from non-ordnance items. EFFICIENCY measures the fraction of detected ordnance retained after discrimination, while the REJECTION RATIO measures the fraction of false alarms rejected. Both measures are defined relative to performance at the demonstrator-supplied level below which all responses are considered noise, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

e. All scoring factors are generated utilizing the Standardized UXO Probability and Plot Program, version 3.1.1.

1.2.2 Scoring Factors

Factors to be measured and evaluated as part of this demonstration include:

a. Response Stage ROC curves:

(1) Probability of Detection (P_d^{res}).

(2) Probability of False Positive (P_{fp}^{res}).

(3) Background Alarm Rate (BAR^{res}) or Probability of Background Alarm (P_{BA}^{res}).

b. Discrimination Stage ROC curves:

(1) Probability of Detection (P_d^{disc}).

(2) Probability of False Positive (P_{fp}^{disc}).

(3) Background Alarm Rate (BAR^{disc}) or Probability of Background Alarm (P_{BA}^{disc}).

c. Metrics:

(1) Efficiency (E).

(2) False Positive Rejection Rate (R_{fp}).

(3) Background Alarm Rejection Rate (R_{BA}).

d. Other:

(1) Probability of Detection by Size and Depth.

(2) Classification by type (i.e., 20-mm, 40-mm, 105-mm, etc.).

(3) Location accuracy.

(4) Equipment setup, calibration time and corresponding man-hour requirements.

(5) Survey time and corresponding man-hour requirements.

(6) Reacquisition/resurvey time and man-hour requirements (if any).

(7) Downtime due to system malfunctions and maintenance requirements.

1.3 STANDARD AND NONSTANDARD INERT ORDNANCE TARGETS

The standard and nonstandard ordnance items emplaced in the test areas are listed in Table 1. Standardized targets are members of a set of specific ordnance items that have identical properties to all other items in the set (caliber, configuration, size, weight, aspect ratio, material, filler, magnetic remanence, and nomenclature). Nonstandard targets are ordnance items having properties that differ from those in the set of standardized targets.

TABLE 1. INERT ORDNANCE TARGETS

Standard Type	Nonstandard (NS)
20-mm Projectile M55	20-mm Projectile M55
	20-mm Projectile M97
40-mm Grenades M385	40-mm Grenades M385
40-mm Projectile MKII Bodies	40-mm Projectile M813
BDU-28 Submunition	
BLU-26 Submunition	
M42 Submunition	
57-mm Projectile APC M86	
60-mm Mortar M49A3	60-mm Mortar (JPG)
	60-mm Mortar M49
2.75-inch Rocket M230	2.75-inch Rocket M230
	2.75-inch Rocket XM229
MK 118 ROCKEYE	
81-mm Mortar M374	81-mm Mortar (JPG)
	81-mm Mortar M374
105-mm HEAT Rounds M456	
105-mm Projectile M60	105-mm Projectile M60
155-mm Projectile M483A1	155-mm Projectile M483A
	500-lb Bomb
	M75 Submunition

JPG = Jefferson Proving Ground.
HEAT = high-explosive antitank

SECTION 2. DEMONSTRATION

2.1 DEMONSTRATOR INFORMATION

2.1.1 Demonstrator Point of Contact (POC) and Address

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2.1.2 System Description (provided by demonstrator)

Dual EM61 MKII Towed Array:

This system will be employed to survey the Calibration Lanes, Blind Grid, Open Field, and the Active Response Site. During the fall of 2003, NAEVA developed and field tested a new towed-array system for the Geonics EM61 MKII. Two 1m x 0.5m coils were encased in a durable poly-plastic sled that rests directly on the ground. Coil heights can be adjusted using inflatable air bladders within the sled, but are typically maintained at the standard height of 40cm above the ground, equivalent to mounting the coils on their standard wheels. The system is towed by an eight-wheeled Argo all-terrain vehicle. A 16-foot tongue attaches the coil assembly to the Argo and maintains sufficient separation so that the vehicle does not influence the geophysical data. A single Global Positioning System (GPS) sensor is mounted over the center of the two coils to provide real-time positional tracking capabilities. System electronics are securely mounted in the vehicle's rear compartment while the data loggers are located in the driver's compartment to allow continuous monitoring of system function.

The system was designed with the goal of quickly collecting the highest quality geophysical data on a modular, reusable platform. The smooth-bottomed sled allows the system to negotiate rough terrain without the jarring and associated mechanical noise usually found in wheel-mounted systems. Light-weight and durable, the poly-plastic shell is composed of several pieces that can be quickly replaced if field repairs are necessary. In addition, the coils are fully enclosed during operation, allowing the towed-array a degree of weather-proofing not usually found in geophysical equipment.

The EM61 is a time-domain electromagnetic instrument designed to detect, with high spatial resolution, shallow ferrous and non-ferrous metallic objects. The applicability of the instrument for (Ordnance and Explosives) OE detection has been widely demonstrated at sites across the United States. Each instrument consists of two air-cored coils (1m x 0.5m), batteries, processing electronics, and a digital data recorder. The larger of the two coils functions as the electromagnetic (EM) source and receiver and is positioned 40 cm below a second receiver coil. Secondary currents induced in both coils are measured in millivolts (mV).

Geonics has recently updated their standard EM61 system to the EM61 MKII. The primary difference in the MKII system is the use of multiple time-gates; the time after the electromagnetic pulse is generated that the receiver coil measures the response. Standard EM61's offer a single time-gate in both the bottom and the top coils. While the top coil time-gate is unchanged, the MKII records early, middle, and late channels from the bottom coil. The late time-gate (third channel) corresponds to the standard EM61 while the earlier time-gates offer enhanced capabilities for the detection of smaller metallic objects. Data from all three channels will be stored and processed during the demonstrations at APG.

Single EM61 MKII/man-portable:

This system will be employed to survey the Calibration lanes, the Blind Grid, the mogul and the woods scenarios. In an effort to maintain the highest standards for quality data acquisition in an area suspected to have small munitions, the EM61 will be operated in a litter/strecher configuration, where the coils are supported by 12-foot long fiberglass poles and transported by two operators. The data logger and backpack will be controlled by the operator at the back of the system. Coil height, consistent with the towed-array at 40 cm, will be maintained through the use of harnesses worn by both operators. NAEVA has found data quality in the tandem configuration to be superior to wheeled operation in all but the smoothest terrain.

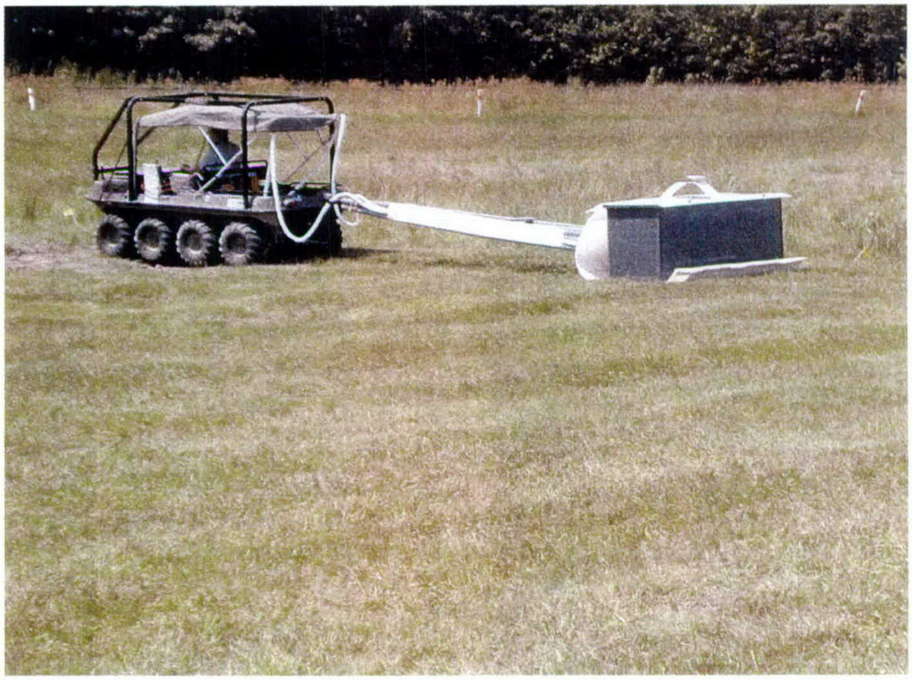

Figure 1. Dual EM61 MKII/Towed Array.

2.1.3 Data Processing Description (provided by demonstrator)

All towed-array data will be collected with real-time GPS data positioning from an antenna mounted between the two coils. Electromagnetic data will be collected at a rate of 10 readings/second which equates to more than one reading per foot. GPS locations will be logged at a rate of one reading/second. Real-time corrections from the GPS base receiver are broadcast to the roving GPS unit via a radio link. The GPS and electromagnetic data will be recorded in a single binary file on an Alegro field computer running Geonics' ML61MK2A software. This file is converted to a standard American Standard Code for Information Interchange (ASCII) file using Geonics' Multi61 Mark2 software. To maintain straight line profiling and to minimize the occurrence of gaps within the data, polyvinyl chloride (PVC) pin flags will be used as ground control. The flags will be set in parallel lines across the area of investigation with alternating colors signifying the data collection paths. Pin flags will be spaced eight feet apart resulting in one pass with the array every four feet. Previous experience has shown that this spacing minimizes the occurrence of gaps between passes as well as providing overlapping coverage of the coil-to-coil gap inherent in the array. Additionally, navigation and real time field coverage will be aided by the use of StarPal software running on a Panasonic Toughbook computer linked to the GPS.

In areas of extremely rough terrain (mogul scenarios and the woods at APG), a single EM61 MKII will be hand-operated by field personnel. Data will be collected at a rate of 10 readings/second along lines spaced two feet apart. Raw binary data is collected on an Alegro portable field computer using EM61 MKIIA Software. This file is converted to a standard ASCII file using Geonics' DAT61 MKII software.

Whether operating the towed-array or the hand-operated system, all geophysical mapping in open areas will make use of real-time GPS data positioning. In the case of the towed-array, the rover antenna will be mounted between the two coils and an offset will be applied during the post-processing to produce the actual coil positions. The rover antenna can be mounted directly over the single coil in hand-operated mode so that no offset is necessary.

In areas where GPS satellite coverage is inadequate, such as the wooded scenario at APG, NAEVA will utilize tape measures and painted ropes to maintain accurate data positioning. Tape measures will be used with the existing control points to create a series of square grids to cover the area. Painted ropes will be placed every 25 feet, perpendicular to the direction of data collection. Evenly spaced, painted marks on the ropes will allow the data collection team to maintain straight-line profiling over the area of investigation. Once all the data is collected, the control points will be used to transform the data from local coordinates to Geodetic Coordinates for scoring submittal. NAEVA has successfully used this method at numerous UXO sites where GPS coverage is not available.

Data Processing:

The geophysical data will be temporarily stored in the instrument logger during data collection and then downloaded into a laptop computer for on-site review and editing. Using Geosoft's Oasis Montaj software, a track plot of the instrument's GPS positions will be created

to ensure that adequate data coverage has been achieved. For those areas without GPS coverage, Geonics' DAT61 MKII software will be employed to correct the EM61 positioning using the fiducial marks entered in the data. Preliminary contour maps will then be created for field review of each survey area. Once in-field processing and review is completed, the data will be electronically transferred to NAEVA's Virginia office for analysis/target selection.

Geosoft's Oasis Montaj UXO software package will be employed to post-process and contour the raw data, and to identify potential UXO targets. The program identifies peak amplitude responses of the frequency associated with, but not limited to, UXO items. Anomalies may generate multiple target designations depending on individual signature characteristics.

Geophysical data processing includes the following:

- Instrument drift correction (leveling);
- Lag correction;
- Digital filtering and enhancement (if necessary);
- Gridding of data;
- Selection of all anomalies;
- Selection of targets for intrusive characterization;
- Preparation of geophysical and target maps.

Once NAEVA has completed the steps described above, the data will be forwarded to our subcontractor, AETC, for discrimination processing and final dig list development. AETC will only evaluate targets selected by NAEVA Geophysics. The first step will be to invert the measured EM61 MKII data using a three-axis dipole model. AETC's EM61 fit algorithm determines the best set of induced dipole model parameters that account for the spatial variation of the EM61 signal as the sensor is moved over the object. The model parameters are target X,Y location and depth, three dipole response coefficients corresponding to the principle axes of the target, and the three angles that describe the orientation of the target. There is a set of three response coefficients for each of the EM61 MKII's four time gates. The magnitude of the response coefficients scales with the size of the target. An empirical relationship will be used to translate the sum of the target response coefficients into an equivalent UXO caliber. The relationship between the three response coefficients tells us something about target shape. Cylindrical objects like most UXO have one large coefficient and two smaller, equal coefficients. Plate-like objects nominally have two large and one small coefficient.

Under controlled measurements, both the forward dipole model and fit algorithm have been found to be highly effective in describing EM61 measurements over buried ordnance. The accuracy of the fit algorithm has been found to limited by poor quality data. In particular, closely spaced and accurately positioned measurements by the EM61 sensor are important for good fit results. Also, the model only describes the EM61 signal from compact objects and does not apply to extended objects such as utility lines.

2.1.4 Data Submission Format

Data were submitted for scoring in accordance with data submission protocols outlined in the Standardized UXO Technology Demonstration Site Handbook. These submitted data are not included in this report in order to protect ground truth information.

2.1.5 Demonstrator Quality Assurance (QA) and Quality Control (QC) (provided by demonstrator)

Overview of Quality Control (QC):

To establish confidence in the data reliability, tests will be conducted in a systematic manner throughout the duration of the fieldwork. Various types of quality control data are generated prior to, during, and after all data collection sessions.

Daily: A location identified as having no subsurface metal will be designated as a calibration point. Readings will be collected in a stationary position over the calibration point to ensure a stable and repeatable response was exhibited. During this time, a metallic item will be placed in a standard position with respect to the coils, and the instrument's response will be observed. The item will then be removed, and static readings continued. This test is performed daily to establish that the instrument is functioning properly, as indicated by a stable and repeatable response. The calibration point will also document the continued accurate performance of the GPS equipment.

A second location will be established over a buried item of known response, likely within one of the Calibration Lanes. At the start and end of each field day, two lines will be collected bi-directionally across the item along the same survey line. The data will then be reviewed for consistent response, positioning, and to determine an appropriate lag correction.

During Data Collection: Upon completion of the original collection of a data set, approximately 3-percent of the line footage for each surveyed area will be recollected as a check of instrument repeatability and positioning. The repeat lines will be saved to separate files and used to create profiles that provide direct comparison with the original data. Each profile will be evaluated for repeatability in both instrument response and data positioning.

Overview of Quality Assurance (QA):

For purposes of this investigation, Quality Assurance (QA) is defined as the procedures to be employed during the demonstration. All of the procedures are designed to provide excellent data quality while maximizing production during the field efforts.

All towed-array data will be collected with real-time GPS data positioning from an antenna mounted between the two coils. Electromagnetic data will be collected at a rate of 10 readings/second which equates to more than one reading per foot. GPS locations will be logged at a rate of one reading/second. To maintain straight line profiling and to minimize the occurrence of gaps within the data, PVC pin flags will be used as ground control. The flags will be set in parallel lines across the area of investigation with alternating colors signifying the data

collection paths. Pin flags will be spaced eight feet apart resulting in one pass with the array every four feet. Previous experience has shown that this spacing minimizes the occurrence of gaps between passes as well as providing overlapping coverage of the coil-to-coil gap inherent in the array. While the GPS has a listed accuracy of 3 cm, the expected accuracy of resultant target selections is signified by a circle with a one-foot radius around each target.

NAEVA's hand-operated system will use GPS for data positioning in areas such as the Mogul Challenge where satellite coverage is available. In such areas the data collection procedures will be identical to those described above with the exception that the line spacing will be reduced to two feet. NAEVA does not expect to be able to maintain satellite coverage in the Wooded Area at APG. Tape measures will be used in conjunction with the established control points to create a series of square survey cells to completely cover the area of investigation. Within each survey cell, data collection will be controlled using a series of marked survey ropes positioned at 25-foot intervals perpendicular to the survey line direction. Alternating color codes painted on the ropes at two-foot intervals facilitate straight line profiling with the instrumentation during data collection. Additionally, the ropes will serve as a point where the operator manually enters marks, or fiducials, into the data stream. The data is then repositioned between the fiducials to account for the changes in velocity that occur as the instrument is carried across variable terrain conditions (i.e. slope, deadfall, vines, etc.). The inconsistent and difficult terrain expected at the site dictate this relatively short fiducial separation (25 feet) to accommodate changes in velocity where greater care is necessary to navigate the instrument safely and effectively across the site.

2.1.6 Additional Records

The following record(s) by this vendor can be accessed via the Internet as MicroSoft Word documents at www.uxotestsites.org.

2.2 APG SITE INFORMATION

2.2.1 Location

The APG Standardized Test Site is located within a secured range area of the Aberdeen Area of APG. The Aberdeen Area of APG is located approximately 30 miles northeast of Baltimore at the northern end of the Chesapeake Bay. The Standardized Test Site encompasses 17 acres of upland and lowland flats, woods, and wetlands.

2.2.2 Soil Type

According to the soils survey conducted for the entire area of APG in 1998, the test site consists primarily of Elkton Series type soil (ref 2). The Elkton Series consists of very deep, slowly permeable, poorly drained soils. These soils formed in silty aeolin sediments and the underlying loamy alluvial and marine sediments. They are on upland and lowland flats and in depressions of the Mid-Atlantic Coastal Plain. Slopes range from 0 to 2 percent.

ERDC conducted a site-specific analysis in May of 2002 (ref 3). The results basically matched the soil survey mentioned above. Seventy percent of the samples taken were classified as silty loam. The majority (77-percent) of the soil samples had a measured water content between 15- and 30-percent with the water content decreasing slightly with depth.

For more details concerning the soil properties at the APG test site, go to www.uxotestsites.org on the web to view the entire soils description report.

2.2.3 Test Areas

A description of the test site areas at APG is included in Table 2.

TABLE 2. TEST SITE AREAS

Area	Description
Calibration Grid	Contains 14 standard ordnance items buried in six positions at various angles and depths to allow demonstrator equipment calibration.
Blind Grid	Contains 400 grid cells in a 0.2-hectare (0.5 acre) site. The center of each grid cell contains ordnance, clutter or nothing.

SECTION 3. FIELD DATA

3.1 DATE OF FIELD ACTIVITIES (10 and 22 August 2004)

3.2 AREAS TESTED/NUMBER OF HOURS

Areas tested and total number of hours operated at each site are summarized in Table 3.

TABLE 3. AREAS TESTED AND NUMBER OF HOURS

Area	Number of Hours
Calibration Lanes	4.50
Blind Grid	5.25

3.3 TEST CONDITIONS

3.3.1 Weather Conditions

An APG weather station located approximately one mile west of the test site was used to record average temperature and precipitation on a half hour basis for each day of operation. The temperatures listed in Table 4 represent the average temperature during field operations from 0700 to 1700 hours while precipitation data represents a daily total amount of rainfall. Hourly weather logs used to generate this summary are provided in Appendix B.

TABLE 4. TEMPERATURE/PRECIPITATION DATA SUMMARY

Date, 2004	Average Temperature, ^{o}F	Total Daily Precipitation, in.
10 August	79.22	0.00

3.3.2 Field Conditions

NAEVA surveyed the Blind Grid on 10 August 2004. The Calibration Lane and Blind Grid had several muddy areas due to rain prior to testing.

3.3.3 Soil Moisture

Three soil probes were placed at various locations within the site to capture soil moisture data: Calibration, Mogul, and Wooded areas. Measurements were collected in percent moisture and were taken twice daily (morning and afternoon) from five different soil depths (1 to 6 in., 6 to 12 in., 12 to 24 in., 24 to 36 in., and 36 to 48 in.) from each probe. Soil moisture logs are included in Appendix C.

3.4 FIELD ACTIVITIES

3.4.1 Setup/Mobilization

These activities included initial mobilization and daily equipment preparation and break down. A four-person crew took 1-hour and 50 minutes to perform the initial setup and mobilization. There was 1-hour and 35 minutes of daily equipment preparation and end of the day equipment break down lasted did not take place.

3.4.2 Calibration

NAEVA spent a total of 4 hours in the calibration lanes, 1-hour and 40 minutes of which was spent collecting data. An additional 30 minutes was spent calibrating while surveying the Blind Grid.

3.4.3 Downtime Occasions

Occasions of downtime are grouped into five categories: equipment/data checks or equipment maintenance, equipment failure and repair, weather, Demonstration Site issues, or breaks/lunch. All downtime is included for the purposes of calculating labor costs (section 5) except for downtime due to Demonstration Sit e issues. Demonstration Site issues, while noted in the Daily Log, are considered non-chargeable downtime for the purposes of calculating labor costs and are not discussed. Breaks and lunches are discussed in this section and billed to the total Site Survey area.

3.4.3.1 Equipment/data checks, maintenance. Equipment data checks and maintenance activities accounted for 15 minutes of site usage time. These activities included changing out batteries and routine data checks to ensure the data was being properly recorded/collected. NAEVA spent an additional 45 minutes for breaks and lunches.

3.4.3.2 Equipment failure or repair. No time was needed to resolve equipment failures that occurred while surveying the Blind Grid.

3.4.3.3 Weather. No weather delays occurred during the survey.

3.4.4 Data Collection

NAEVA spent a total time of 5 hours and 15 minutes in the Blind Grid area, 2 hours and 40 minutes of which was spent collecting data.

3.4.5 Demobilization

The NAEVA survey crew went on to conducted a full demonstration of the site. Therefore, demobilization did not occur until 22 August 2004. On that day, it took the crew 1-hour and 35 minutes to break down and pack up their equipment.

3.5 PROCESSING TIME

NAEVA submitted the raw data from the demonstration activities on the last day of the demonstration, as required. The scoring submittal data was also provided within the required 30-day timeframe.

3.6 DEMONSTRATOR'S FIELD PERSONNEL

Leif Riddervold: Operations Manager
Alexander Kostera: General Field Support
Ashley Mowery: Towed Array System Operator
David Garey: Title: Person Portable System Operator

3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD

NAEVA surveyed the Blind Grid in two directions, in a linear fashion. NAEVA once surveyed starting in the northeast corner of the grid and in an east/west direction. Secondly, NAEVA started in the southeast corner of the grid and surveyed in a north/south direction.

3.8 SUMMARY OF DAILY LOGS

Daily logs capture all field activities during this demonstration and are located in Appendix D. Activities pertinent to this specific demonstration are indicated in highlighted text.

SECTION 4. TECHNICAL PERFORMANCE RESULTS

4.1 ROC CURVES USING ALL ORDNANCE CATEGORIES

Figure 2 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive. Figure 3 shows both probabilities plotted against their respective probability of background alarm. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

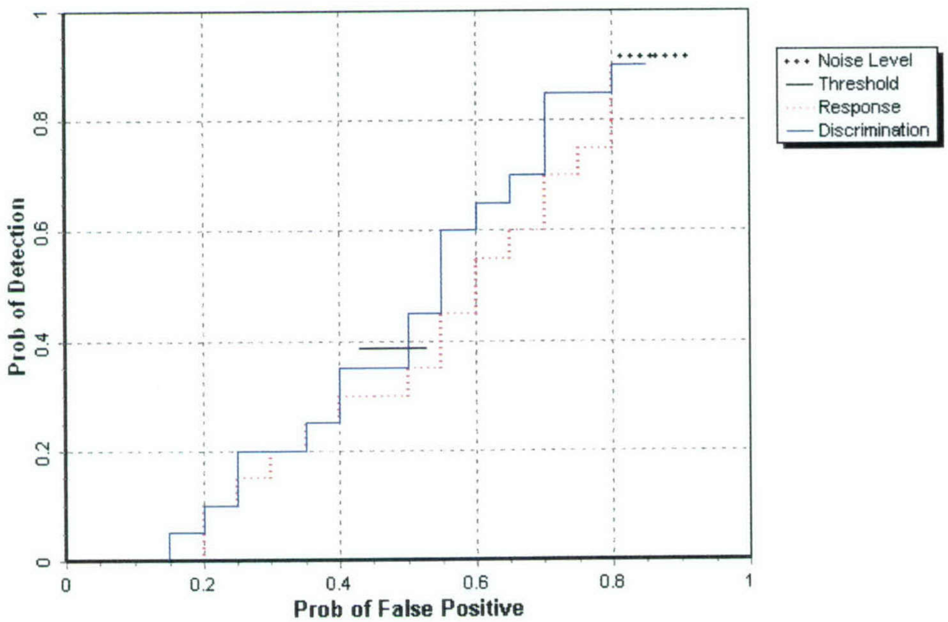

Figure 2. EM61 MKII towed blind grid probability of detection for response and discrimination stages versus their respective probability of false positive over all ordnance categories combined.

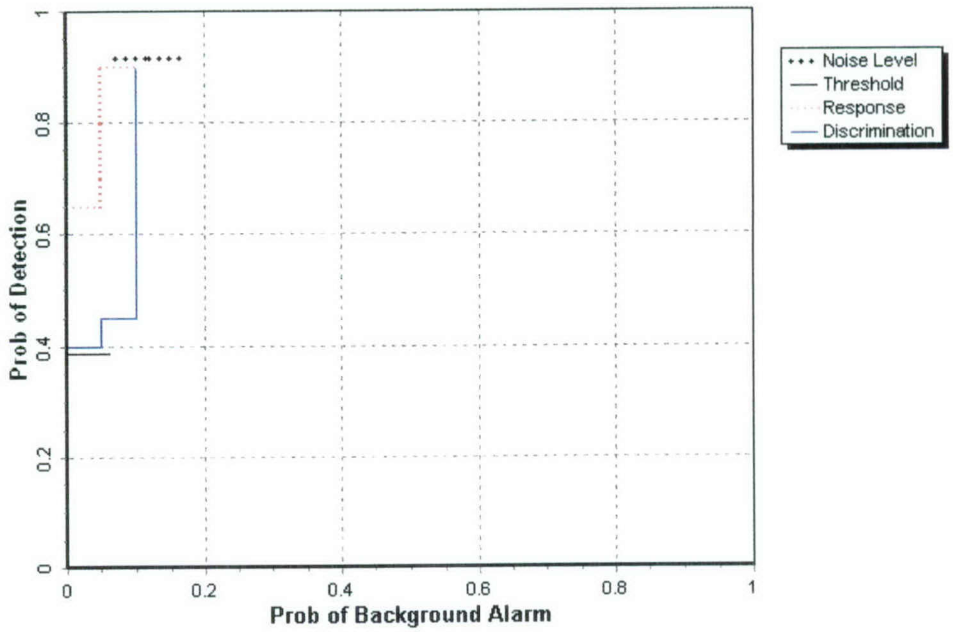

Figure 3. EM61 MKII towed blind grid probability of detection for response and discrimination stages versus their respective probability of background alarm over all ordnance categories combined.

4.2 ROC CURVES USING ORDNANCE LARGER THAN 20 MM

Figure 4 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive when only targets larger than 20 mm are scored. Figure 5 shows both probabilities plotted against their respective probability of background alarm. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

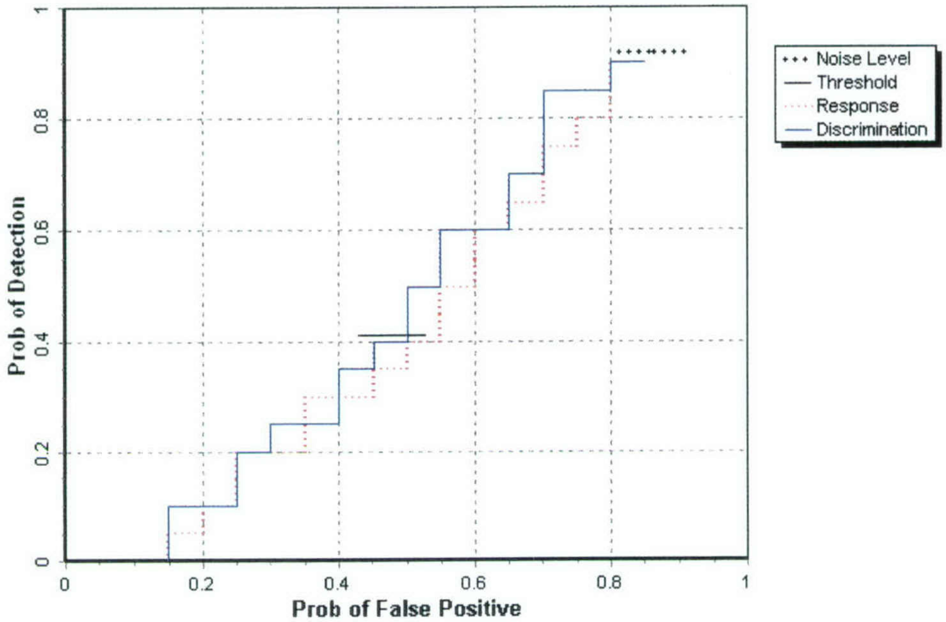

Figure 4. EM61 MKII towed blind grid probability of detection for response and discrimination stages versus their respective probability of false positive for all ordnance larger than 20 mm.

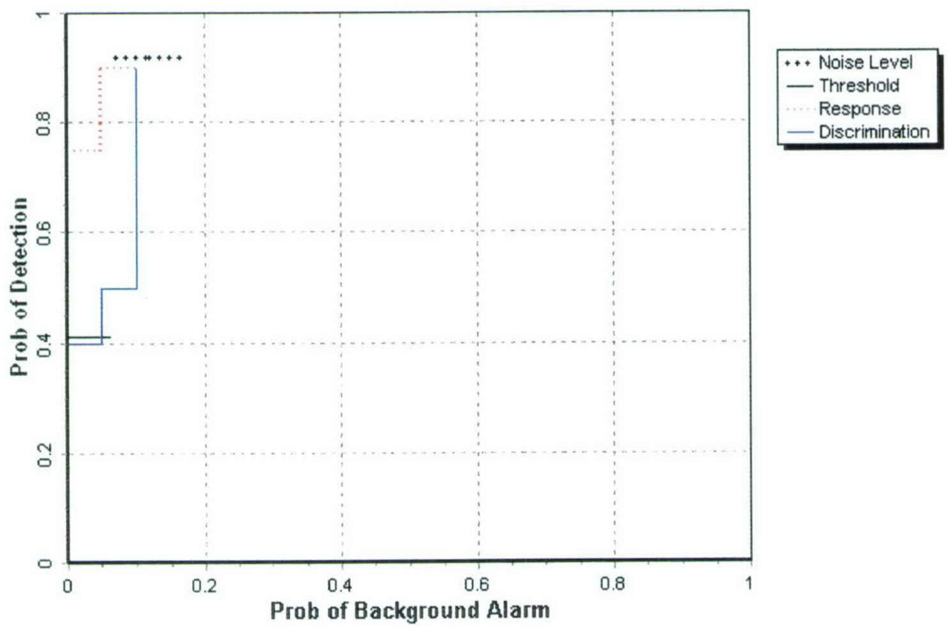

Figure 5. EM61 MKII towed blind grid probability of detection for response and discrimination stages versus their respective probabilities of background alarm for all ordnance larger than 20 mm.

4.3 PERFORMANCE SUMMARIES

Results for the Blind Grid test broken out by size, depth and nonstandard ordnance are presented in Table 5 (for cost results, see section 5). Results by size and depth include both standard and nonstandard ordnance. The results by size show how well the demonstrator did at detecting/discriminating ordnance of a certain caliber range (see app A for size definitions). The results are relative to the number of ordnance items emplaced. Depth is measured from the geometric center of anomalies.

The RESPONSE STAGE results are derived from the list of anomalies above the demonstrator-provided noise level. The results for the DISCRIMINATION STAGE are derived from the demonstrator's recommended threshold for optimizing UXO field cleanup by minimizing false digs and maximizing ordnance recovery. The lower 90 percent confidence limit on probability of detection and P_{fp} was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results in Table 5 have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

TABLE 5. SUMMARY OF BLIND GRID RESULTS FOR THE EM61 MKII

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.90	0.90	0.90	0.95	0.85	0.90	1.00	0.95	0.55
P_d Low 90% Conf	0.86	0.85	0.80	0.88	0.76	0.66	0.94	0.87	0.37
P_d Upper 90% Conf	0.95	0.97	0.97	0.99	0.94	0.99	1.00	1.00	0.76
P_{fp}	0.85	-	-	-	-	-	0.85	0.85	1.00
P_{fp} Low 90% Conf	0.80	-	-	-	-	-	0.79	0.74	0.63
P_{fp} Upper 90% Conf	0.91	-	-	-	-	-	0.93	0.90	1.00
P_{ba}	0.10	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.40	0.40	0.40	0.35	0.40	0.50	0.50	0.45	0.00
P_d Low 90% Conf	0.31	0.30	0.26	0.26	0.27	0.27	0.36	0.32	0.00
P_d Upper 90% Conf	0.46	0.49	0.50	0.47	0.52	0.73	0.59	0.58	0.15
P_{fp}	0.50	-	-	-	-	-	0.45	0.50	1.00
P_{fp} Low 90% Conf	0.41	-	-	-	-	-	0.33	0.37	0.63
P_{fp} Upper 90% Conf	0.55	-	-	-	-	-	0.53	0.59	1.00
P_{ba}	0.00	-	-	-	-	-	-	-	-

Response Stage Noise Level: -0.66
Recommended Discrimination Stage Threshold: 110.50

Note: The recommended discrimination stage threshold values are provided by the demonstrator.

4.4 EFFICIENCY, REJECTION RATES, AND TYPE CLASSIFICATION

Efficiency and rejection rates are calculated to quantify the discrimination ability at specific points of interest on the ROC curve: (1) at the point where no decrease in P_d is suffered (i.e., the efficiency is by definition equal to one) and (2) at the operator selected threshold. These values are reported in Table 6.

TABLE 6. EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	0.42	0.44	0.88
With No Loss of P_d	1.00	0.00	0.00

At the demonstrator's recommended setting, the ordnance items that were detected and correctly discriminated were further scored on whether their correct type could be identified (table 8). Correct type examples include "20-mm projectile, 105-mm HEAT Projectile, and 2.75-inch Rocket". A list of the standard type declaration required for each ordnance item was provided to demonstrators prior to testing. For example, the standard type for the three example items are 20mmP, 105H, and 2.75in, respectively.

TABLE 7. CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS UXO

Size	Percentage Correct
Small	6.7
Medium	8.3
Large	20.0
Overall	9.4

Note: The demonstrator did not attempt to provide type classification.

4.5 LOCATION ACCURACY

The mean location error and standard deviations appear in Table 8. These calculations are based on average missed depth for ordnance correctly identified in the discrimination stage. Depths are measured from the closest point of the ordnance to the surface. For the Blind Grid, only depth errors are calculated, since (X, Y) positions are known to be the centers of each grid square.

TABLE 8. MEAN LOCATION ERROR AND STANDARD DEVIATION (M)

	Mean	Standard Deviation
Depth	0.06	0.18

SECTION 5. ON-SITE LABOR COSTS

A standardized estimate for labor costs associated with this effort was calculated as follows: the first person at the test site was designated "supervisor", the second person was designated "data analyst", and the third and following personnel were considered "field support". Standardized hourly labor rates were charged by title: supervisor at $95.00/hour, data analyst at $57.00/hour, and field support at $28.50/hour.

Government representatives monitored on-site activity. All on-site activities were grouped into one of ten categories: initial setup/mobilization, daily setup/stop, calibration, collecting data, downtime due to break/lunch, downtime due to equipment failure, downtime due to equipment/data checks or maintenance, downtime due to weather, downtime due to demonstration site issue, or demobilization. See Appendix D for the daily activity log. See section 3.4 for a summary of field activities.

The standardized cost estimate associated with the labor needed to perform the field activities is presented in Table 9. Note that calibration time includes time spent in the Calibration Lanes as well as field calibrations. "Site survey time" includes daily setup/stop time, collecting data, breaks/lunch, downtime due to equipment/data checks or maintenance, downtime due to failure, and downtime due to weather.

TABLE 9. ON-SITE LABOR COSTS

	No. People	Hourly Wage	Hours	Cost
Initial Setup				
Supervisor	1	$95.00	1.83	$173.85
Data Analyst	1	57.00	1.83	104.31
Field Support	2	28.50	1.83	104.31
SubTotal				**$382.47**
Calibration				
Supervisor	1	$95.00	4.50	$427.50
Data Analyst	1	57.00	4.50	256.50
Field Support	2	28.50	4.50	256.50
SubTotal				**$940.50**
Site Survey				
Supervisor	1	$95.00	5.25	$498.75
Data Analyst	1	57.00	5.25	299.25
Field Support	2	28.50	5.25	299.25
SubTotal				**$1,097.25**

See notes at end of table.

TABLE 9 (CONT'D)

	No. People	Hourly Wage	Hours	Cost
Demobilization				
Supervisor	1	$95.00	1.58	$150.10
Data Analyst	1	57.00	1.58	90.06
Field Support	0	28.50	1.58	0.00
Subtotal				**$240.16**
Total				**$2,660.38**

Notes: Calibration time includes time spent in the Calibration Lanes as well as calibration before each data run.

Site Survey time includes daily setup/stop time, collecting data, breaks/lunch, downtime due to system maintenance, failure, and weather.

SECTION 6. COMPARISON OF RESULTS TO DATE

No comparisons to date.

SECTION 7. APPENDIXES

APPENDIX A. TERMS AND DEFINITIONS

GENERAL DEFINITIONS

Anomaly: Location of a system response deemed to warrant further investigation by the demonstrator for consideration as an emplaced ordnance item.

Detection: An anomaly location that is within R_{halo} of an emplaced ordnance item.

Emplaced Ordnance: An ordnance item buried by the government at a specified location in the test site.

Emplaced Clutter: A clutter item (i.e., non-ordnance item) buried by the government at a specified location in the test site.

R_{halo}: A pre-determined radius about the periphery of an emplaced item (clutter or ordnance) within which a location identified by the demonstrator as being of interest is considered to be a response from that item. If multiple declarations lie within R_{halo} of any item (clutter or ordnance), the declaration with the highest signal output within the R_{halo} will be utilized. For the purpose of this program, a circular halo 0.5 meters in radius will be placed around the center of the object for all clutter and ordnance items less than 0.6 meters in length. When ordnance items are longer than 0.6 meters, the halo becomes an ellipse where the minor axis remains 1 meter and the major axis is equal to the length of the ordnance plus 1 meter.

Small Ordnance: Caliber of ordnance less than or equal to 40 mm (includes 20-mm projectile, 40-mm projectile, submunitions BLU-26, BLU-63, and M42).

Medium Ordnance: Caliber of ordnance greater than 40-mm and less than or equal to 81-mm (includes 57-mm projectile, 60-mm mortar, 2.75 in. Rocket, MK118 Rockeye, 81-mm mortar).

Large Ordnance: Caliber of ordnance greater than 81-mm (includes 105-mm HEAT, 105-mm projectile, 155-mm projectile, 500-pound bomb).

Shallow: Items buried less than 0.3 meter below ground surface.

Medium: Items buried greater than or equal to 0.3 meter and less than 1 meter below ground surface.

Deep: Items buried greater than or equal to 1 meter below ground surface.

Response Stage Noise Level: The level that represents the point below which anomalies are not considered detectable. Demonstrators are required to provide the recommended noise level for the Blind Grid test area.

Discrimination Stage Threshold: The demonstrator selected threshold level that they believe provides optimum performance of the system by retaining all detectable ordnance and rejecting the maximum amount of clutter. This level defines the subset of anomalies the demonstrator would recommend digging based on discrimination.

Binomially Distributed Random Variable: A random variable of the type which has only two possible outcomes, say success and failure, is repeated for n independent trials with the probability p of success and the probability 1-p of failure being the same for each trial. The number of successes x observed in the n trials is an estimate of p and is considered to be a binomially distributed random variable.

RESPONSE AND DISCRIMINATION STAGE DATA

The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver operating characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}) and those that do not correspond to any known item, termed background alarms.

The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the RESPONSE STAGE, the demonstrator provides the scoring committee with the location and signal strength of all anomalies that the demonstrator has deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such, and to reject clutter. For the same locations as in the RESPONSE STAGE anomaly list, the DISCRIMINATION STAGE list contains the output of the algorithms applied in the discrimination-stage processing. This list is prioritized based on the demonstrator's determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that the demonstrator believes will provide "optimum" system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

Note: The two lists provided by the demonstrator contain identical numbers of potential target locations. They differ only in the priority ranking of the declarations.

RESPONSE STAGE DEFINITIONS

Response Stage Probability of Detection (P_d^{res}): P_d^{res} = (No. of response-stage detections)/(No. of emplaced ordnance in the test site).

Response Stage False Positive (fp^{res}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Response Stage Probability of False Positive (P_{fp}^{res}): P_{fp}^{res} = (No. of response-stage false positives)/(No. of emplaced clutter items).

Response Stage Background Alarm (ba^{res}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Response Stage Probability of Background Alarm (P_{ba}^{res}): Blind Grid only: P_{ba}^{res} = (No. of response-stage background alarms)/(No. of empty grid locations).

Response Stage Background Alarm Rate (BAR^{res}): Open Field only: BAR^{res} = (No. of response-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{res}, P_{fp}^{res}, P_{ba}^{res}, and BAR^{res} are functions of t^{res}, the threshold applied to the response-stage signal strength. These quantities can therefore be written as $P_d^{res}(t^{res})$, $P_{fp}^{res}(t^{res})$, $P_{ba}^{res}(t^{res})$, and $BAR^{res}(t^{res})$.

DISCRIMINATION STAGE DEFINITIONS

Discrimination: The application of a signal processing algorithm or human judgment to response-stage data that discriminates ordnance from clutter. Discrimination should identify anomalies that the demonstrator has high confidence correspond to ordnance, as well as those that the demonstrator has high confidence correspond to non-ordnance or background returns. The former should be ranked with highest priority and the latter with lowest.

Discrimination Stage Probability of Detection (P_d^{disc}): P_d^{disc} = (No. of discrimination-stage detections)/(No. of emplaced ordnance in the test site).

Discrimination Stage False Positive (fp^{disc}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Discrimination Stage Probability of False Positive (P_{fp}^{disc}): P_{fp}^{disc} = (No. of discrimination stage false positives)/(No. of emplaced clutter items).

Discrimination Stage Background Alarm (ba^{disc}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Discrimination Stage Probability of Background Alarm (P_{ba}^{disc}): P_{ba}^{disc} = (No. of discrimination-stage background alarms)/(No. of empty grid locations).

Discrimination Stage Background Alarm Rate (BAR^{disc}): BAR^{disc} = (No. of discrimination-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{disc}, P_{fp}^{disc}, P_{ba}^{disc}, and BAR^{disc} are functions of t^{disc}, the threshold applied to the discrimination-stage signal strength. These quantities can therefore be written as $P_d^{disc}(t^{disc})$, $P_{fp}^{disc}(t^{disc})$, $P_{ba}^{disc}(t^{disc})$, and $BAR^{disc}(t^{disc})$.

RECEIVER-OPERATING CHARACERISTIC (ROC) CURVES

ROC curves at both the response and discrimination stages can be constructed based on the above definitions. The ROC curves plot the relationship between P_d versus P_{fp} and P_d versus BAR or P_{ba} as the threshold applied to the signal strength is varied from its minimum (t_{min}) to its maximum (t_{max}) value.[1] Figure A-1 shows how P_d versus P_{fp} and P_d versus BAR are combined into ROC curves. Note that the "res" and "disc" superscripts have been suppressed from all the variables for clarity.

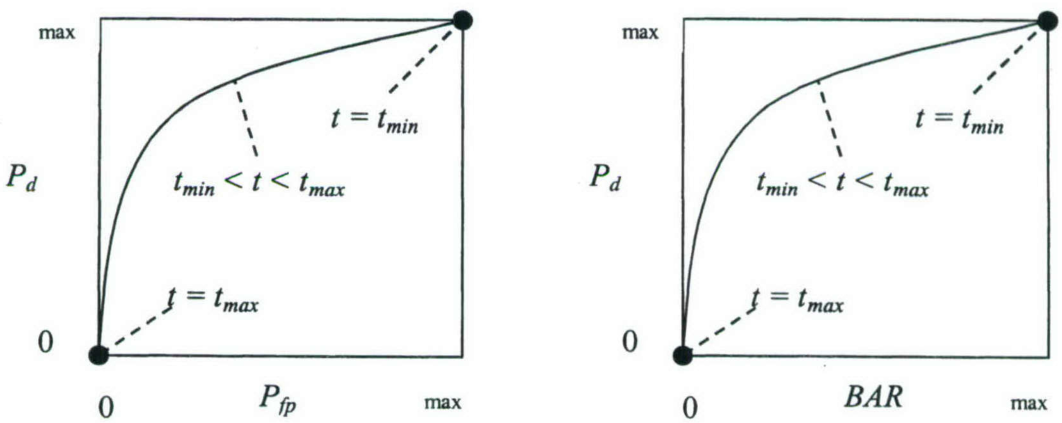

Figure A-1. ROC curves for open field testing. Each curve applies to both the response and discrimination stages.

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[1]Strictly speaking, ROC curves plot the P_d versus P_{ba} over a pre-determined and fixed number of detection opportunities (some of the opportunities are located over ordnance and others are located over clutter or blank spots). In an open field scenario, each system suppresses its signal strength reports until some bare-minimum signal response is received by the system. Consequently, the open field ROC curves do not have information from low signal-output locations, and, furthermore, different contractors report their signals over a different set of locations on the ground. These ROC curves are thus not true to the strict definition of ROC curves as defined in textbooks on detection theory. Note, however, that the ROC curves obtained in the Blind Grid test sites are true ROC curves.

METRICS TO CHARACTERIZE THE DISCRIMINATION STAGE

The demonstrator is also scored on efficiency and rejection ratio, which measure the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from non-ordnance items. The efficiency measures the amount of detected ordnance retained by the discrimination, while the rejection ratio measures the fraction of false alarms rejected. Both measures are defined relative to the entire response list, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

Efficiency (E): $E = P_d^{disc}(t^{disc})/P_d^{res}(t_{min}^{res})$; Measures (at a threshold of interest), the degree to which the maximum theoretical detection performance of the sensor system (as determined by the response stage tmin) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the ordnance initially detected in the response stage was retained at the specified threshold in the discrimination stage, t^{disc}.

False Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}^{disc}(t^{disc})/P_{fp}^{res}(t_{min}^{res})]$; Measures (at a threshold of interest), the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage tmin). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

Background Alarm Rejection Rate (R_{ba}):

Blind Grid: $R_{ba} = 1 - [P_{ba}^{disc}(t^{disc})/P_{ba}^{res}(t_{min}^{res})]$.
Open Field: $R_{ba} = 1 - [BAR^{disc}(t^{disc})/BAR^{res}(t_{min}^{res})])$.

Measures the degree to which the discrimination stage correctly rejects background alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all background alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

CHI-SQUARE COMPARISON EXPLANATION:

The Chi-square test for differences in probabilities (or 2 x 2 contingency table) is used to analyze two samples drawn from two different populations to see if both populations have the same or different proportions of elements in a certain category. More specifically, two random samples are drawn, one from each population, to test the null hypothesis that the probability of event A (some specified event) is the same for both populations (ref 3).

A 2 x 2 contingency table is used in the Standardized UXO Technology Demonstration Site Program to determine if there is reason to believe that the proportion of ordnance correctly detected/discriminated by demonstrator X's system is significantly degraded by the more challenging terrain feature introduced. The test statistic of the 2 x 2 contingency table is the

Chi-square distribution with one degree of freedom. Since an association between the more challenging terrain feature and relatively degraded performance is sought, a one-sided test is performed. A significance level of 0.05 is chosen which sets a critical decision limit of 2.71 from the Chi-square distribution with one degree of freedom. It is a critical decision limit because if the test statistic calculated from the data exceeds this value, the two proportions tested will be considered significantly different. If the test statistic calculated from the data is less than this value, the two proportions tested will be considered not significantly different.

An exception must be applied when either a 0 or 100 percent success rate occurs in the sample data. The Chi-square test cannot be used in these instances. Instead, Fischer's test is used and the critical decision limit for one-sided tests is the chosen significance level, which in this case is 0.05. With Fischer's test, if the test statistic is less than the critical value, the proportions are considered to be significantly different.

Standardized UXO Technology Demonstration Site examples, where blind grid results are compared to those from the open field and open field results are compared to those from one of the scenarios, follow. It should be noted that a significant result does not prove a cause and effect relationship exists between the two populations of interest; however, it does serve as a tool to indicate that one data set has experienced a degradation in system performance at a large enough level than can be accounted for merely by chance or random variation. Note also that a result that is not significant indicates that there is not enough evidence to declare that anything more than chance or random variation within the same population is at work between the two data sets being compared.

Demonstrator X achieves the following overall results after surveying each of the three progressively more difficult areas using the same system (results indicate the number of ordnance detected divided by the number of ordnance emplaced):

	Blind Grid	Open Field	Moguls
P_d^{res}	100/100 = 1.0	8/10 = .80	20/33 = .61
P_d^{disc}	80/100 = 0.80	6/10 = .60	8/33 = .24

P_d^{res}: BLIND GRID versus OPEN FIELD. Using the example data above to compare probabilities of detection in the response stage, all 100 ordnance out of 100 emplaced ordnance items were detected in the blind grid while 8 ordnance out of 10 emplaced were detected in the open field. Fischer's test must be used since a 100 percent success rate occurs in the data. Fischer's test uses the four input values to calculate a test statistic of 0.0075 that is compared against the critical value of 0.05. Since the test statistic is less than the critical value, the smaller response stage detection rate (0.80) is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause and effect relationship exists between the change in survey area and degradation in performance, it does indicate that the detection ability of demonstrator X's system seems to have been degraded in the open field relative to results from the blind grid using the same system.

P_d^{disc}: BLIND GRID versus OPEN FIELD. Using the example data above to compare probabilities of detection in the discrimination stage, 80 out of 100 emplaced ordnance items were correctly discriminated as ordnance in blind grid testing while 6 ordnance out of 10 emplaced were correctly discriminated as such in open field-testing. Those four values are used to calculate a test statistic of 1.12. Since the test statistic is less than the critical value of 2.71, the two discrimination stage detection rates are considered to be not significantly different at the 0.05 level of significance.

P_d^{res}: OPEN FIELD versus MOGULS. Using the example data above to compare probabilities of detection in the response stage, 8 out of 10 and 20 out of 33 are used to calculate a test statistic of 0.56. Since the test statistic is less than the critical value of 2.71, the two response stage detection rates are considered to be not significantly different at the 0.05 level of significance.

P_d^{disc}: OPEN FIELD versus MOGULS. Using the example data above to compare probabilities of detection in the discrimination stage, 6 out of 10 and 8 out of 33 are used to calculate a test statistic of 2.98. Since the test statistic is greater than the critical value of 2.71, the smaller discrimination stage detection rate is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause and effect relationship exists between the change in survey area and degradation in performance, it does indicate that the ability of demonstrator X to correctly discriminate seems to have been degraded by the mogul terrain relative to results from the flat open field using the same system.

APPENDIX B. DAILY WEATHER LOGS

TABLE B-1. WEATHER LOG

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/09/2004 00:00:00	63.9	64.5	63.1	92.3	0
08/09/2004 01:00:00	62.5	63.2	61.6	94.3	0
08/09/2004 02:00:00	61.4	62.7	60.5	95.9	0
08/09/2004 03:00:00	62.5	63.1	61.7	92.2	0
08/09/2004 04:00:00	61.2	61.9	60.5	94.7	0
08/09/2004 05:00:00	59.6	60.7	58.7	97.8	0
08/09/2004 06:00:00	59.1	60.1	58.7	99.2	0
08/09/2004 07:00:00	63.6	66.6	59.6	94.1	0
08/09/2004 08:00:00	69.1	71.9	66.2	79.72	0
08/09/2004 09:00:00	74.8	77.3	71.6	67.47	0
08/09/2004 10:00:00	79.2	81.1	76.8	58.36	0
08/09/2004 11:00:00	81.1	82.5	79.6	53.82	0
08/09/2004 12:00:00	82.5	83.7	81.5	51.69	0
08/09/2004 13:00:00	81.3	82.7	79.7	58.89	0
08/09/2004 14:00:00	81.1	82.7	80	56.81	0
08/09/2004 15:00:00	83.1	84.3	80.6	52.18	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/09/2004 16:00:00	83.4	84.3	82.7	48.25	0
08/09/2004 17:00:00	83	83.6	82.5	47.32	0
08/09/2004 18:00:00	82.3	83	81.3	48.78	0
08/09/2004 19:00:00	78.1	81.5	73.4	61.48	0
08/09/2004 20:00:00	71.7	73.9	69.5	78.96	0
08/09/2004 21:00:00	69	70.3	68	87.8	0
08/09/2004 22:00:00	67.4	69	66.4	92.1	0
08/09/2004 23:00:00	67	68	65.8	94.4	0
08/10/2004 00:00:00	65.7	66.1	65.1	98.1	0
08/10/2004 01:00:00	65.3	66.1	64.5	99.3	0
08/10/2004 02:00:00	64.8	65.4	64.3	100	0
08/10/2004 03:00:00	64.4	65	63.7	100	0
08/10/2004 04:00:00	64.8	65.4	64.3	100	0
08/10/2004 05:00:00	65.1	65.6	64.6	100	0
08/10/2004 06:00:00	66	66.8	65	100	0
08/10/2004 07:00:00	68.9	70.6	66.7	100	0
08/10/2004 08:00:00	72.1	74.3	70.3	97.1	0
08/10/2004 09:00:00	74.5	75.8	73.9	84.7	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/10/2004 10:00:00	75.7	76.6	75.1	81	0
08/10/2004 11:00:00	78.3	80.7	76	76.42	0
08/10/2004 12:00:00	81.8	82.9	80.4	69.37	0
08/10/2004 13:00:00	83.1	84.8	81.9	62.09	0
08/10/2004 14:00:00	84.7	85.6	83.9	59.27	0
08/10/2004 15:00:00	84.3	84.9	82.9	60.23	0
08/10/2004 16:00:00	84.3	85	83.2	55.61	0
08/10/2004 17:00:00	83.7	84.5	83	63.21	0
08/10/2004 18:00:00	82.9	83.4	81.9	65.59	0
08/10/2004 19:00:00	80.9	82.3	80	70.39	0
08/10/2004 20:00:00	79.2	80.3	78.2	74.83	0
08/10/2004 21:00:00	78.1	78.7	77.5	78.07	0
08/10/2004 22:00:00	76.9	77.7	76.2	82.6	0
08/10/2004 23:00:00	77.3	78.6	76.3	83.5	0
08/11/2004 00:00:00	77.8	78.5	76.8	82.7	0
08/11/2004 01:00:00	76.9	77.4	76.4	83.9	0
08/11/2004 02:00:00	76.6	77.1	76.2	83.3	0
08/11/2004 03:00:00	76.1	76.8	75.4	81.7	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/11/2004 04:00:00	75.4	76.1	74.3	81.7	0
08/11/2004 05:00:00	74.3	74.9	73.5	83.8	0
08/11/2004 06:00:00	73.1	73.9	72.1	86.4	0
08/11/2004 07:00:00	74.7	75.8	73.6	84	0
08/11/2004 08:00:00	76.4	77.6	75.4	80.5	0
08/11/2004 09:00:00	77.9	78.7	76.9	77.23	0
08/11/2004 10:00:00	78.9	79.8	78.1	75.36	0
08/11/2004 11:00:00	79.9	81.4	78.8	74.5	0
08/11/2004 12:00:00	81.6	82.6	81.1	71.39	0
08/11/2004 13:00:00	83	84.3	81.1	67.88	0
08/11/2004 14:00:00	83.8	84.9	83.1	67.09	0
08/11/2004 15:00:00	84.5	85.4	83.7	65.78	0
08/11/2004 16:00:00	82.3	84.7	81.1	71.17	0
08/11/2004 17:00:00	76.4	81.5	71.1	83.6	0.02
08/11/2004 18:00:00	73.6	75	72.1	90.4	0
08/11/2004 19:00:00	74	74.6	73.4	92.3	0
08/11/2004 20:00:00	72.4	73.8	70.9	91.6	0
08/11/2004 21:00:00	70.9	71.5	70.4	96.4	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/11/2004 22:00:00	71.4	72.2	70.4	89.6	0
08/11/2004 23:00:00	69.8	71.2	68.9	95.4	0
08/12/2004 00:00:00	70.5	71.5	69.6	94.9	0
08/12/2004 01:00:00	70.1	71.9	68.1	96.4	0
08/12/2004 02:00:00	68.9	69.9	68	99.6	0
08/12/2004 03:00:00	69.5	70.4	68.7	100	0
08/12/2004 04:00:00	69.5	70.7	67.7	100	0
08/12/2004 05:00:00	70.1	71.1	68.2	100	0
08/12/2004 06:00:00	70.6	71.4	69.8	100	0
08/12/2004 07:00:00	72.3	74	70.6	100	0
08/12/2004 08:00:00	75.2	77.1	73.3	96.4	0
08/12/2004 09:00:00	78.2	79.7	76.6	87.2	0
08/12/2004 10:00:00	80.6	81.7	79.3	77.29	0
08/12/2004 11:00:00	81.1	82.4	80.2	73.52	0
08/12/2004 12:00:00	81.7	82.9	81.1	76.49	0
08/12/2004 13:00:00	82.5	83.4	81.5	76.27	0
08/12/2004 14:00:00	83	84.1	82.1	74.95	0
08/12/2004 15:00:00	84.7	86.1	83.1	72.95	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/12/2004 16:00:00	83.9	85.7	78	71.63	0
08/12/2004 17:00:00	77.2	78.2	76.6	88	0
08/12/2004 18:00:00	74.5	77.1	71.4	92.1	0.64
08/12/2004 19:00:00	73.1	73.8	72.5	98.1	0
08/12/2004 20:00:00	72.9	73.3	72.5	99.8	0
08/12/2004 21:00:00	73.3	73.7	73	100	0.09
08/12/2004 22:00:00	73.1	73.8	72.1	99	0.01
08/12/2004 23:00:00	73.3	73.8	72.9	97.5	0
08/13/2004 00:00:00	73.6	73.9	73.2	96.6	0.01
08/13/2004 01:00:00	73.4	73.8	73	98.4	0.05
08/13/2004 02:00:00	74.4	75.1	73.5	96	0
08/13/2004 03:00:00	74	74.9	73.3	93.6	0
08/13/2004 04:00:00	73.6	73.9	73.2	93.9	0
08/13/2004 05:00:00	73.6	74	73.2	93.4	0
08/13/2004 06:00:00	73.3	73.8	72.9	92.2	0
08/13/2004 07:00:00	73.2	73.6	72.9	91.1	0
08/13/2004 08:00:00	73.6	74	73	91.2	0
08/13/2004 09:00:00	74.2	74.9	73	86.2	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/13/2004 10:00:00	73.5	74	72.8	86.6	0
08/13/2004 11:00:00	73.7	75.5	72.6	85.7	0
08/13/2004 12:00:00	75.4	76.3	74.3	82.4	0
08/13/2004 13:00:00	73.7	74.8	72.6	91	0.04
08/13/2004 14:00:00	74.4	75.3	73.5	89.1	0
08/13/2004 15:00:00	77.3	78.9	75.1	81	0
08/13/2004 16:00:00	79.4	80.8	78.3	75.48	0
08/13/2004 17:00:00	79.8	81.5	78.4	70.4	0
08/13/2004 18:00:00	78.2	79.4	76.6	74.21	0
08/13/2004 19:00:00	75.3	77.1	73.8	84.2	0
08/13/2004 20:00:00	73.2	74.3	72.1	89.3	0
08/13/2004 21:00:00	71.1	72.4	70.2	95.5	0
08/13/2004 22:00:00	71.6	72.3	70.5	90.6	0
08/13/2004 23:00:00	71.5	72.2	70.7	82.2	0
08/14/2004 00:00:00	70.3	71.3	69.5	81.9	0
08/14/2004 01:00:00	69.9	70.5	69.2	81.3	0
08/14/2004 02:00:00	69.3	69.9	68.8	82.6	0
08/14/2004 03:00:00	68.3	69.3	67.7	86.7	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/14/2004 04:00:00	67.9	68.3	67.4	87.2	0
08/14/2004 05:00:00	67.6	68.2	67	83.3	0
08/14/2004 06:00:00	66.4	67.6	64.9	87.2	0.03
08/14/2004 07:00:00	65.4	66.4	64.6	94.6	0.01
08/14/2004 08:00:00	66.3	67.3	65.8	91.4	0
08/14/2004 09:00:00	68.1	69.8	67	87	0
08/14/2004 10:00:00	70.7	72.4	69.3	80.3	0
08/14/2004 11:00:00	73.6	74.6	72	74.33	0
08/14/2004 12:00:00	73	74	71.3	77.61	0
08/14/2004 13:00:00	71.5	72	71	83	0
08/14/2004 14:00:00	71.6	72.5	71	84.5	0
08/14/2004 15:00:00	72	72.7	71.5	82.5	0
08/14/2004 16:00:00	71.7	72.1	70.9	83.4	0
08/14/2004 17:00:00	70	71.2	68.9	91.7	0.02
08/14/2004 18:00:00	69	69.5	68.7	97.1	0.01
08/14/2004 19:00:00	68.5	69	68.1	98.8	0.02
08/14/2004 20:00:00	67.4	68.6	66.4	96.6	0.04
08/14/2004 21:00:00	66.5	67	66.1	95.8	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/14/2004 22:00:00	66.3	66.9	65.8	97.6	0
08/14/2004 23:00:00	66.7	67.4	66.1	98.4	0
08/15/2004 00:00:00	67.3	67.7	66.9	98.9	0
08/15/2004 01:00:00	67.7	68	67.4	99	0
08/15/2004 02:00:00	67.2	67.9	66.7	99.8	0
08/15/2004 03:00:00	66.4	67.3	65.5	100	0
08/15/2004 04:00:00	65.8	66.7	65.1	100	0
08/15/2004 05:00:00	65.8	66.3	64.4	100	0
08/15/2004 06:00:00	65	65.8	64.2	100	0
08/15/2004 07:00:00	67.1	68.5	65.5	99.3	0
08/15/2004 08:00:00	69.5	70.5	68.2	91.4	0
08/15/2004 09:00:00	72	74.2	70	84	0
08/15/2004 10:00:00	75.4	76.9	73.5	73.18	0
08/15/2004 11:00:00	77	78.7	75.8	70.35	0
08/15/2004 12:00:00	76.9	78.8	75.2	74.11	0
08/15/2004 13:00:00	78	79.1	77	71.53	0
08/15/2004 14:00:00	78.1	78.7	77.3	69.87	0
08/15/2004 15:00:00	77.6	78.1	76.9	72.41	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/15/2004 16:00:00	76.3	77.2	75.8	73.48	0
08/15/2004 17:00:00	75.5	76.3	74.6	76.1	0
08/15/2004 18:00:00	74.2	75	73.3	78.96	0
08/15/2004 19:00:00	72.6	73.7	71.8	85.8	0
08/15/2004 20:00:00	71.2	72.4	69.7	89.6	0
08/15/2004 21:00:00	69.2	70.1	68.3	95.3	0
08/15/2004 22:00:00	68.5	69.3	67.5	97	0
08/15/2004 23:00:00	67.3	68.2	66.3	99.2	0
08/16/2004 00:00:00	67.3	67.9	66.4	100	0
08/16/2004 01:00:00	68	68.7	67.5	100	0
08/16/2004 02:00:00	68.6	69	68.3	100	0
08/16/2004 03:00:00	69	69.4	68.6	100	0
08/16/2004 04:00:00	68.9	69.4	68.3	99.4	0
08/16/2004 05:00:00	68.5	68.8	68.2	99.7	0
08/16/2004 06:00:00	68.3	68.7	68	100	0
08/16/2004 07:00:00	68.7	69	68.2	99.9	0
08/16/2004 08:00:00	69.5	70.8	68.7	98.5	0.01
08/16/2004 09:00:00	72.7	75.9	70.1	89.2	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/16/2004 10:00:00	76.5	77.4	75.4	73.86	0
08/16/2004 11:00:00	78.3	80.1	77.1	67.26	0
08/16/2004 12:00:00	80.1	81.7	78.7	59.34	0
08/16/2004 13:00:00	81.4	82.5	80.5	52.94	0
08/16/2004 14:00:00	82.1	83.9	81.2	52.27	0
08/16/2004 15:00:00	82.7	83.9	81.5	50.65	0
08/16/2004 16:00:00	83.1	84.5	82	51.38	0
08/16/2004 17:00:00	82.3	83.6	81.5	55.06	0
08/16/2004 18:00:00	81.4	82.3	80.6	61.68	0
08/16/2004 19:00:00	77.8	81.4	73.9	68.05	0
08/16/2004 20:00:00	71.3	74	69	84.3	0
08/16/2004 21:00:00	68.6	69.5	67.7	94	0
08/16/2004 22:00:00	67.1	68.2	66.3	98	0
08/16/2004 23:00:00	65.5	66.7	64.6	99.2	0
08/17/2004 00:00:00	64.5	65.1	63.7	99.5	0
08/17/2004 01:00:00	63.4	64.2	62.5	99.4	0
08/17/2004 02:00:00	63.6	65.5	62.4	95.9	0
08/17/2004 03:00:00	62.5	63.1	61.4	98.1	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/17/2004 04:00:00	62.5	64.8	60.9	97.9	0
08/17/2004 05:00:00	63.1	63.8	61.6	96.5	0
08/17/2004 06:00:00	61.6	62.5	60.8	98.7	0
08/17/2004 07:00:00	64.5	66.9	62.2	97.3	0
08/17/2004 08:00:00	68.8	70.2	66.7	85.8	0
08/17/2004 09:00:00	71.9	74.1	70	78.27	0
08/17/2004 10:00:00	75.1	76.3	73.5	72.25	0
08/17/2004 11:00:00	76.7	79.2	75.3	68.8	0
08/17/2004 12:00:00	78.8	80.1	77.6	65.42	0
08/17/2004 13:00:00	80.1	81.3	79.4	61.37	0
08/17/2004 14:00:00	80.9	81.9	80.1	60.62	0
08/17/2004 15:00:00	80.5	82	79.3	63.04	0
08/17/2004 16:00:00	81	82.6	79.4	64.64	0
08/17/2004 17:00:00	80.5	81.4	78.7	64.49	0
08/17/2004 18:00:00	78.5	79.4	77	67.79	0
08/17/2004 19:00:00	77.3	77.8	76.2	74.18	0
08/17/2004 20:00:00	74.5	76.6	73.3	86.9	0
08/17/2004 21:00:00	73.3	73.9	72.6	88.9	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/17/2004 22:00:00	72.7	73.6	72.1	83.6	0
08/17/2004 23:00:00	72.3	73.3	69.6	89.1	0.02
08/18/2004 00:00:00	69.4	70.6	68.2	92.7	0
08/18/2004 01:00:00	68.3	68.8	68	97.2	0.02
08/18/2004 02:00:00	68.5	69	67.7	99.1	0.01
08/18/2004 03:00:00	68	68.9	67.2	100	0.02
08/18/2004 04:00:00	69.1	69.6	68.6	100	0
08/18/2004 05:00:00	68.9	69.6	68.2	100	0
08/18/2004 06:00:00	67.6	68.7	66.6	100	0
08/18/2004 07:00:00	68.7	70.5	67.2	100	0
08/18/2004 08:00:00	71.9	73.3	70.4	99.4	0
08/18/2004 09:00:00	74.2	75	73.1	92.9	0
08/18/2004 10:00:00	76	77.3	74.3	86.7	0
08/18/2004 11:00:00	78.1	80.1	76.6	80.9	0
08/18/2004 12:00:00	80.6	82	79	73.1	0
08/18/2004 13:00:00	82	82.8	81.3	66.53	0
08/18/2004 14:00:00	82.1	83.1	81	62.45	0
08/18/2004 15:00:00	82.1	83.4	81.3	58.14	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/18/2004 16:00:00	81.8	82.7	81	69.95	0
08/18/2004 17:00:00	81.3	82.9	80.1	74.08	0
08/18/2004 18:00:00	80.3	80.9	78.3	75.72	0
08/18/2004 19:00:00	75.6	78.4	72.6	78.92	0
08/18/2004 20:00:00	71	73	70	94.3	0
08/18/2004 21:00:00	70.9	71.7	70.3	95.9	0
08/18/2004 22:00:00	71.8	72.8	71.2	96.6	0
08/18/2004 23:00:00	72.4	72.9	71.7	98	0
08/19/2004 00:00:00	71.5	72	70.8	98.7	0
08/19/2004 01:00:00	71.1	71.8	70.6	99.7	0
08/19/2004 02:00:00	73.5	75	71.3	97.5	0
08/19/2004 03:00:00	74.5	74.9	73.9	92	0
08/19/2004 04:00:00	74.7	75.1	74.3	91.5	0
08/19/2004 05:00:00	74.5	75.1	73.9	92	0
08/19/2004 06:00:00	74.1	74.5	73.7	93.3	0
08/19/2004 07:00:00	74.4	75.8	73.5	94.5	0
08/19/2004 08:00:00	76	76.8	75.4	90.8	0
08/19/2004 09:00:00	76.9	77.5	76.1	88.1	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/19/2004 10:00:00	77.2	78	76.3	87.7	0
08/19/2004 11:00:00	77.9	79.3	77.1	87.1	0
08/19/2004 12:00:00	80	81.4	78.2	82.3	0
08/19/2004 13:00:00	82.2	83.8	80.7	76.63	0
08/19/2004 14:00:00	84	85.4	82.5	74.38	0
08/19/2004 15:00:00	85.5	86.8	84.5	71.58	0
08/19/2004 16:00:00	86.6	87.3	85.6	66.98	0
08/19/2004 17:00:00	86.4	87	86.1	67.7	0
08/19/2004 18:00:00	85	86.6	82.5	72.57	0
08/19/2004 19:00:00	82.1	83.2	80.9	80	0
08/19/2004 20:00:00	81	81.8	80	82.8	0
08/19/2004 21:00:00	81.4	82	80.8	83.2	0
08/19/2004 22:00:00	80.2	81.2	79.5	89	0
08/19/2004 23:00:00	78.1	79.7	77.4	94.8	0
08/20/2004 00:00:00	77.4	78.1	76.7	97	0
08/20/2004 01:00:00	76.7	77.6	75.6	98.1	0
08/20/2004 02:00:00	75.7	76.6	74.5	99.3	0
08/20/2004 03:00:00	75.4	76.2	74.6	99.6	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/20/2004 04:00:00	73.9	75.5	73	100	0
08/20/2004 05:00:00	72.6	73.5	71.9	100	0
08/20/2004 06:00:00	72.3	73.2	71.4	100	0
08/20/2004 07:00:00	73.8	76.2	71.8	99.4	0
08/20/2004 08:00:00	78.2	80.3	75.9	90	0
08/20/2004 09:00:00	81.7	83.8	79.9	81.5	0
08/20/2004 10:00:00	85.2	86.7	83.2	71.27	0
08/20/2004 11:00:00	87.8	89.3	86.2	64.95	0
08/20/2004 12:00:00	88.8	89.5	88	67.26	0
08/20/2004 13:00:00	89.7	90.7	88.7	59.08	0
08/20/2004 14:00:00	90.7	91.4	90.1	57.61	0
08/20/2004 15:00:00	90.2	91.1	88.6	58.57	0
08/20/2004 16:00:00	88.2	89.6	87.1	64.35	0
08/20/2004 17:00:00	87.2	87.8	86.6	67.05	0
08/20/2004 18:00:00	85.9	87.6	84.4	69	0
08/20/2004 19:00:00	84	84.9	83.6	78.34	0
08/20/2004 20:00:00	83.5	84.1	83.1	79.91	0
08/20/2004 21:00:00	83.1	83.6	82.6	79.57	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/20/2004 22:00:00	82.7	83.4	82	80.8	0
08/20/2004 23:00:00	82.1	82.5	81.7	82.4	0
08/21/2004 00:00:00	81.3	82.1	80.6	83.9	0
08/21/2004 01:00:00	80.4	81	79.8	84.3	0
08/21/2004 02:00:00	80.3	80.7	79.8	81.8	0
08/21/2004 03:00:00	80.3	80.9	79.7	82.2	0
08/21/2004 04:00:00	79.8	80.5	79.2	84.1	0
08/21/2004 05:00:00	79.1	79.7	78.6	86.6	0
08/21/2004 06:00:00	79.1	79.4	78.7	88	0
08/21/2004 07:00:00	79	79.7	78.5	89.5	0
08/21/2004 08:00:00	79.8	80.4	79.2	87.3	0
08/21/2004 09:00:00	79.9	80.4	79.2	86.7	0
08/21/2004 10:00:00	80.2	80.7	79.8	84.1	0
08/21/2004 11:00:00	80.4	81.2	79.6	85.1	0
08/21/2004 12:00:00	81.2	81.8	80.6	81.5	0
08/21/2004 13:00:00	82	83	81.3	80	0
08/21/2004 14:00:00	81.9	82.9	81.4	78.84	0
08/21/2004 15:00:00	78	82.3	74.8	87.5	0.09

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/21/2004 16:00:00	75.4	76.6	73.5	90.1	0
08/21/2004 17:00:00	73.1	73.8	72.5	85.5	0
08/21/2004 18:00:00	72.6	73.3	72	81.4	0
08/21/2004 19:00:00	71.4	73.1	69.7	77	0
08/21/2004 20:00:00	68.9	70.2	68	82	0
08/21/2004 21:00:00	67.4	68.7	66.3	80.1	0
08/21/2004 22:00:00	64.4	66.5	62.1	88.2	0
08/21/2004 23:00:00	62.1	62.8	61.5	96.2	0
08/22/2004 00:00:00	61.6	63.7	59.5	94.1	0
08/22/2004 01:00:00	60.2	60.7	59.5	98.8	0
08/22/2004 02:00:00	61	61.8	60.1	98.1	0
08/22/2004 03:00:00	61.4	61.8	60.9	96.2	0
08/22/2004 04:00:00	60.9	61.4	59.9	96.8	0
08/22/2004 05:00:00	59.4	60.3	58.2	98.2	0
08/22/2004 06:00:00	59.8	60.5	59.3	97.3	0
08/22/2004 07:00:00	62.4	64.4	60.1	89	0
08/22/2004 08:00:00	65.4	66.6	64.2	75.13	0
08/22/2004 09:00:00	67.3	68.6	66.1	64.98	0

Date & Time	Average Temp (°F)	Maximum Temp (°F)	Minimum Temp (°F)	Relative Humidity (%)	Total Precip (in)
08/22/2004 10:00:00	69.4	71.1	67.7	61.8	0
08/22/2004 11:00:00	71.2	72.7	70.1	56.72	0
08/22/2004 12:00:00	72.9	73.9	72	56.6	0
08/22/2004 13:00:00	74.4	75.8	72.8	53.29	0
08/22/2004 14:00:00	76	77	74.8	45.31	0
08/22/2004 15:00:00	77	78.1	76	41.59	0
08/22/2004 16:00:00	78.1	79	77.2	42.35	0
08/22/2004 17:00:00	77.5	79.1	75.8	47	0
08/22/2004 18:00:00	74.9	76.2	73.7	55.21	0
08/22/2004 19:00:00	70.6	73.8	66.7	68.67	0
08/22/2004 20:00:00	65.4	68.2	63.9	84.4	0
08/22/2004 21:00:00	62.5	64.6	60.8	92.9	0
08/22/2004 22:00:00	60.6	61.4	59.8	96.3	0
08/22/2004 23:00:00	59.8	60.3	59	98.1	0

APPENDIX C. SOIL MOISTURE

Demonstrator: NAEVA

Date: 8/9/04
Times: 1100 hours, 1430 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Wooded Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Calibration Lanes	0 to 6	1.2	1.0
	6 to 12	20.8	20.5
	12 to 24	28.9	28.7
	24 to 36	36.3	36.3
	36 to 48	39.2	39.0
Blind Grid/Moguls	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

Demonstrator: NAEVA

Date: 8/10/04
Times: 1100 hours, 1400 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Wooded Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Calibration Lanes	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6	4.0	4.0
	6 to 12	25.2	25.3
	12 to 24	39.9	39.5
	24 to 36	36.6	36.9
	36 to 48	40.3	40.1

Demonstrator: NAEVA

Date: 8/11/04
Times: 0900 hours, 1400 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	65.9	65.7
	6 to 12	74.5	75.3
	12 to 24	79.2	79.5
	24 to 36	55.4	55.8
	36 to 48	52.7	52.9
Wooded Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	21.5	21.7
	6 to 12	6.5	6.2
	12 to 24	19.8	19.4
	24 to 36	26.9	26.7
	36 to 48	52.3	52.1
Calibration Lanes	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

Demonstrator: NAEVA

Date: 8/12/04
Times: 0730 hours, 1500 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	66.4	66.0
	6 to 12	74.8	75.0
	12 to 24	79.0	79.3
	24 to 36	55.5	55.3
	36 to 48	52.5	52.6
Wooded Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	22.8	22.5
	6 to 12	6.4	6.3
	12 to 24	19.5	19.4
	24 to 36	26.4	26.1
	36 to 48	52.5	52.3
Calibration Lanes	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

Demonstrator: NAEVA

Date: 8/9/04
Times: 1100 hours, 1430 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	68.0	67.8
	6 to 12	76.8	76.4
	12 to 24	79.9	79.7
	24 to 36	55.7	55.4
	36 to 48	53.7	54.1
Wooded Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	24.8	24.5
	6 to 12	6.9	6.8
	12 to 24	19.7	19.5
	24 to 36	27.9	27.7
	36 to 48	52.8	52.9
Calibration Lanes	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

Demonstrator: NAEVA

Date: 8/17/04
Times: 1100 hours, 1430 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	67.2	67.0
	6 to 12	76.2	76.1
	12 to 24	79.4	79.4
	24 to 36	55.1	55.0
	36 to 48	53.8	53.5
Wooded Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	24.2	24.1
	6 to 12	6.5	6.1
	12 to 24	19.6	19.5
	24 to 36	27.3	27.1
	36 to 48	52.4	52.4
Calibration Lanes	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

Demonstrator: NAEVA

Date: 8/18/04
Times: 0800 hours, 1800 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	67.0	
	6 to 12	76.0	
	12 to 24	79.6	
	24 to 36	55.0	
	36 to 48	53.4	
Wooded Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	24.0	
	6 to 12	6.0	
	12 to 24	19.3	
	24 to 36	26.7	
	36 to 48	52.3	
Calibration Lanes	0 to 6		1.4
	6 to 12		20.2
	12 to 24		28.4
	24 to 36		36.0
	36 to 48		38.4
Blind Grid/Moguls	0 to 6		3.3
	6 to 12		25.0
	12 to 24		38.4
	24 to 36		36.1
	36 to 48		39.5

Demonstrator: NAEVA

Date: 8/18/04
Times: 0800 hours, 1+00 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Wooded Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Calibration Lanes	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6	3.1	2.9
	6 to 12	24.7	24.8
	12 to 24	38.7	38.6
	24 to 36	35.8	36.0
	36 to 48	39.1	39.2

Demonstrator: NAEVA

Date: 8/20/04
Times: 0800 hours, 1700 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Wooded Area	0 to 6		14.2
	6 to 12		5.7
	12 to 24		5.8
	24 to 36		55.9
	36 to 48		57.8
Open Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Calibration Lanes	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6	2.5	
	6 to 12	24.4	
	12 to 24	38.9	
	24 to 36	35.7	
	36 to 48	39.0	

Demonstrator: NAEVA

Date: 8/21/04
Times: 0800 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Wooded Area	0 to 6	14.3	
	6 to 12	5.5	
	12 to 24	5.4	
	24 to 36	55.7	
	36 to 48	57.9	
Open Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Calibration Lanes	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

Demonstrator: NAEVA

Date: 8/18/04
Times: 0800 hours, 1400 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	67.6	67.4
	6 to 12	76.4	76.2
	12 to 24	79.1	79.0
	24 to 36	55.0	54.8
	36 to 48	53.5	53.2
Wooded Area	0 to 6	14.7	14.6
	6 to 12	5.3	5.2
	12 to 24	5.6	5.4
	24 to 36	55.3	55.1
	36 to 48	57.5	57.5
Open Area	0 to 6	24.0	23.7
	6 to 12	6.8	6.7
	12 to 24	19.5	19.0
	24 to 36	27.7	27.5
	36 to 48	52.6	52.3
Calibration Lanes	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

Demonstrator: NAEVA

Date: 8/23/04
Times: 0800 hours, 1400 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Wooded Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Calibration Lanes	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

Demonstrator: NAEVA

Date: 8/24/04
Times: 0800 hours, 1400 hours

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Wooded Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Calibration Lanes	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6		
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

APPENDIX D. DAILY ACTIVITIY LOGS

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	OP Stat Code	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
						TOWED							
8/9/04	4	CALIBRATION LANE	930	1120	110	INITIAL MOBILIZATION	1	INITIAL MOBILIZATION	GPS	NA	LINEAR	SUNNY	MUDDY
8/9/04	4	CALIBRATION LANE	1120	1130	10	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	SUNNY	MUDDY
8/9/04	4	CALIBRATION LANE	1130	1215	45	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
8/9/04	4	CALIBRATION LANE	1215	1330	75	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	SUNNY	MUDDY
8/9/04	4	CALIBRATION LANE	1330	1425	55	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
8/9/04	4	CALIBRATION LANE	1425	1440	15	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	SUNNY	MUDDY
8/9/04	4	CALIBRATION LANE	1440	1520	40	DAILY START/STOP	3	BREAKDOWN END OF OPERATIONS	GPS	NA	LINEAR	SUNNY	MUDDY
8/10/04	4	BLIND TEST GRID	745	920	95	DAILY START/STOP	3	SET UP, BEGIN OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/10/04	4	BLIND TEST GRID	920	935	15	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/10/04	4	BLIND TEST GRID	935	1100	85	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/10/04	4	BLIND TEST GRID	1100	1115	15	DOWNTIME MAINTENANCE CHECK	7	DOWNLOAD DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/10/04	4	BLIND TEST GRID	1115	1230	75	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	OP Stat Code	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
8/10/04	4	BLIND TEST GRID	1230	1245	15	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/10/04	4	BLIND TEST GRID	1245	1330	45	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/10/04	4	OPEN FIELD	1330	1600	150	DAILY START/STOP	3	SET UP GRIDS, OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/10/04	4	OPEN FIELD	1600	1620	20	DAILY START/STOP	3	BREAKDOWN END OF OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/11/04	4	OPEN FIELD	745	925	100	DAILY START/STOP	3	SET UP GRIDS, OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/11/04	4	OPEN FIELD	925	945	20	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/11/04	4	OPEN FIELD	945	1205	140	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/11/04	4	OPEN FIELD	1205	1215	10	DOWNTIME MAINTENANCE CHECK	7	DOWNLOAD DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/11/04	4	OPEN FIELD	1215	1250	35	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/11/04	4	OPEN FIELD	1250	1600	190	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/11/04	4	OPEN FIELD	1600	1615	15	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/11/04	4	OPEN FIELD	1615	1635	20	DAILY START/STOP	3	BREAKDOWN END OF OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	OP Stat Code	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
8/12/04	4	OPEN FIELD	745	825	40	DAILY START/STOP	3	SET UP, BEGIN OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/12/04	4	OPEN FIELD	825	850	25	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/12/04	4	OPEN FIELD	850	1125	155	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/12/04	4	OPEN FIELD	1125	1140	15	EQUIPMENT FAILURE	6	VEHICLE STUCK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/12/04	4	OPEN FIELD	1140	1230	50	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/12/04	4	OPEN FIELD	1230	1240	10	DOWNTIME MAINTENANCE CHECK	7	DOWNLOAD DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/12/04	4	OPEN FIELD	1240	1320	40	EQUIPMENT FAILURE	6	REPLACED BOLT ATTACHING SLED TO FRAME	GPS	NA	LINEAR	CLOUDY	MUDDY
8/12/04	4	OPEN FIELD	1320	1340	20	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/12/04	4	OPEN FIELD	1340	1530	110	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/12/04	4	OPEN FIELD	1530	1540	10	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/12/04	4	OPEN FIELD	1540	1615	35	DAILY START/STOP	3	BREAKDOWN END OF OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/16/04	4	OPEN FIELD	750	900	70	DAILY START/STOP	3	SET UP, BEGIN OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	OP Stat Code	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
8/16/04	4	OPEN FIELD	900	930	30	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/16/04	4	OPEN FIELD	930	1130	120	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/16/04	4	OPEN FIELD	1130	1200	30	DOWNTIME MAINTENANCE CHECK	7	DOWNLOAD DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/16/04	4	OPEN FIELD	1200	1330	90	EQUIPMENT FAILURE	6	DATA CONSOLE CONNECTOR WIRE CAME LOOSE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/16/04	4	OPEN FIELD	1330	1600	150	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/16/04	4	OPEN FIELD	1600	1625	25	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/16/04	4	OPEN FIELD	1625	1640	15	DOWNTIME MAINTENANCE CHECK	7	DOWNLOAD DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/16/04	4	OPEN FIELD	1640	1710	30	DAILY START/STOP	3	BREAKDOWN END OF OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/17/04	4	OPEN FIELD	750	905	75	DAILY START/STOP	3	SET UP, BEGIN OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/17/04	4	OPEN FIELD	905	920	15	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/17/04	4	OPEN FIELD	920	1010	50	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/17/04	4	OPEN FIELD	1010	1125	75	EQUIPMENT FAILURE	6	TRANSMISSION BOLT CAME LOOSE IN VEHICLE	GPS	NA	LINEAR	CLOUDY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	OP Stat Code	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
8/17/04	4	OPEN FIELD	1125	1215	50	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/17/04	4	OPEN FIELD	1215	1225	10	DOWNTIME MAINTENANCE CHECK	7	DOWNLOAD DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/17/04	4	OPEN FIELD	1225	1245	20	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/17/04	4	OPEN FIELD	1245	1600	195	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/17/04	4	OPEN FIELD	1600	1615	15	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/17/04	4	OPEN FIELD	1615	1625	10	DOWNTIME MAINTENANCE CHECK	7	DOWNLOAD DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/17/04	4	OPEN FIELD	1625	1650	25	DAILY START/STOP	3	BREAKDOWN END OF OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	4	OPEN FIELD	745	820	35	DAILY START/STOP	3	SET UP, BEGIN OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	4	OPEN FIELD	820	840	20	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	4	OPEN FIELD	840	940	60	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	4	OPEN FIELD	940	955	15	DOWNTIME MAINTENANCE CHECK	7	DOWNLOAD DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
MAN PORTABLE													
8/18/04	4	CAL LANE	955	1040	45	INITIAL MOBILIZATION	1	INITIAL MOBILIZATION	GPS	NA	LINEAR	CLOUDY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	OP Stat Code	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
8/18/04	2	CAL LANE	1040	1100	20	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	2	CAL LANE	1100	1205	65	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	2	CAL LANE	1205	1245	40	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	2	CAL LANE	1245	1345	60	DOWNTIME MAINTENANCE CHECK	7	DATA CHECK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	2	BLIND TEST GRID	1345	1440	55	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	2	BLIND TEST GRID	1440	1445	5	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	2	BLIND TEST GRID	1445	1550	65	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	2	BLIND TEST GRID	1550	1600	10	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	2	BLIND TEST GRID	1600	1630	30	DAILY START/STOP	3	BREAKDOWN END OF OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	2	WOODS	1040	1205	85	DAILY START/STOP	3	SET UP GRIDS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	2	WOODS	1205	1245	40	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	2	WOODS	1245	1500	135	DAILY START/STOP	3	SET UP GRIDS	GPS	NA	LINEAR	CLOUDY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	OP Stat Code	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
8/18/04	2	WOODS	1500	1600	60	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/18/04	2	WOODS	1600	1630	30	DAILY START/STOP	3	BREAKDOWN END OF OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/19/04	4	MOGULS	740	825	45	DAILY START/STOP	3	SET UP, BEGIN OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/19/04	4	MOGULS	825	840	15	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/19/04	4	MOGULS	840	920	40	DAILY START/STOP	3	SET UP GRIDS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/19/04	4	MOGULS	920	925	5	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/19/04	4	MOGULS	925	1125	120	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/19/04	4	MOGULS	1125	1215	50	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/19/04	4	MOGULS	1215	1320	65	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/19/04	4	MOGULS	1320	1350	30	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/19/04	4	MOGULS	1350	1530	110	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/19/04	4	MOGULS	1530	1555	25	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	OP Stat Code	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
8/19/04	4	MOGULS	1555	1630	35	DAILY START/STOP	3	BREAKDOWN END OF OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	4	MOGULS	745	840	55	DAILY START/STOP	3	SET UP, BEGIN OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	MOGULS	840	900	20	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	MOGULS	900	935	35	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	MOGULS	935	1000	25	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	MOGULS	1000	1035	35	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	MOGULS	1035	1140	65	DOWNTIME MAINTENANCE CHECK	7	DOWNLOAD DATA/DATA CHECK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	MOGULS	1140	1145	5	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	MOGULS	1145	1315	90	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	WOODS	840	1055	135	DAILY START/STOP	3	SET UP, BEGIN OPERATIONS SET UP GRIDS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	WOODS	1315	1415	60	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	WOODS	1415	1440	25	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	OP Stat Code	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
8/20/04	2	WOODS	1440	1555	75	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	WOODS	1555	1605	10	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	WOODS	1605	1630	25	DAILY START/STOP	3	BREAKDOWN END OF OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/2104	2	WOODS	750	815	35	DAILY START/STOP	3	SET UP, BEGIN OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/21/04	2	WOODS	815	830	15	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/2104	2	WOODS	830	1100	150	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/21/04	2	WOODS	1100	1115	15	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/2104	2	WOODS	1115	1150	35	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/21/04	4	WOODS	1150	1230	40	DAILY START/STOP	3	SET UP GRIDS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/2104	4	WOODS	1230	1300	30	DAILY START/STOP	3	BREAKDOWN END OF OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/22/04	2	WOODS	750	830	40	DAILY START/STOP	3	SET UP, BEGIN OPERATIONS	GPS	NA	LINEAR	SUNNY	MUDDY
8/2204	2	WOODS	830	840	10	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	OP Stat Code	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
8/22/04	2	WOODS	840	1035	115	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
8/22/04	2	WOODS	1035	1115	40	DOWNTIME MAINTENANCE CHECK	7	DOWNLOAD DATA/DATA CHECK	GPS	NA	LINEAR	SUNNY	MUDDY
8/22/04	2	WOODS	1115	1200	45	DAILY START/STOP	3	SET UP GRIDS	GPS	NA	LINEAR	SUNNY	MUDDY
8/22/04	2	WOODS	1200	1325	85	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
8/22/04	2	WOODS	1325	1410	45	DOWNTIME MAINTENANCE CHECK	7	DOWNLOAD DATA/DATA CHECK	GPS	NA	LINEAR	SUNNY	MUDDY
8/22/04	2	WOODS	1410	1420	10	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	SUNNY	MUDDY
TOWED CONTINUED													
8/22/04	2	OPEN FIELD	750	840	50	DAILY START/STOP	3	SET UP, BEGIN OPERATIONS	GPS	NA	LINEAR	SUNNY	MUDDY
8/22/04	2	OPEN FIELD	840	850	10	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	SUNNY	MUDDY
8/22/04	2	OPEN FIELD	850	945	55	DAILY START/STOP	3	SET UP GRIDS	GPS	NA	LINEAR	SUNNY	MUDDY
8/22/04	2	OPEN FIELD	945	1015	30	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
8/22/04	2	OPEN FIELD	1015	1115	60	DAILY START/STOP	3	SET UP GRIDS	GPS	NA	LINEAR	SUNNY	MUDDY
8/22/04	2	OPEN FIELD	1325	1400	35	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	OP Stat Code	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
8/22/04	2	OPEN FIELD	1400	1410	10	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	SUNNY	MUDDY
8/22/04	2	OPEN FIELD	1410	1545	95	DEMOBILIZATION	10	DEMOBILIZATION	GPS	NA	LINEAR	SUNNY	MUDDY
8/20/04	2	ACTIVE SITE	1120	1145	25	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	ACTIVE SITE	1145	1210	25	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	ACTIVE SITE	1210	1315	65	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	ACTIVE SITE	1315	1350	35	DEMO/RANGE ISSUE	8	TW FIRING HE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	ACTIVE SITE	1350	1515	85	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	ACTIVE SITE	1515	1540	25	DEMO/RANGE ISSUE	8	TW FIRING HE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	ACTIVE SITE	1540	1550	10	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/20/04	2	ACTIVE SITE	1550	1630	40	DAILY START/STOP	3	BREAKDOWN END OF OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/21/04	2	ACTIVE SITE	750	830	40	DAILY START/STOP	3	SET UP, BEGIN OPERATIONS	GPS	NA	LINEAR	CLOUDY	MUDDY
8/21/04	2	ACTIVE SITE	830	845	15	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	OP Stat Code	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
8/21/04	2	ACTIVE SITE	845	1045	120	COLLECT DATA	4	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
8/21/04	2	ACTIVE SITE	1045	1100	15	CALIBRATE	2	CALIBRATE USING METALLIC SPHERE	GPS	NA	LINEAR	CLOUDY	MUDDY
8/21/04	2	ACTIVE SITE	1100	1150	50	LUNCH/BREAK	5	LUNCH/BREAK	GPS	NA	LINEAR	CLOUDY	MUDDY

APPENDIX E. REFERENCES

1. Standardized UXO Technology Demonstration Site Handbook, DTC Project No. 8-CO-160-000-473, Report No. ATC-8349, March 2002.

2. Aberdeen Proving Ground Soil Survey Report, October 1998.

3. Data Summary, UXO Standardized Test Site: APG Soils Description, May 2002.

4. Yuma Proving Ground Soil Survey Report, May 2003.

APPENDIX F. ABBREVIATIONS

AEC = U.S. Army Environmental Center
APG = Aberdeen Proving Ground
ASCII = American Standard Code for Information Interchange.
ATC = U.S. Army Aberdeen Test Center
EMIS = Electromagnetic Induction Spectroscopy
ERDC = U.S. Army Corps of Engineers Engineering Research and Development Center
ESTCP = Environmental Security Technology Certification Program
EQT = Army Environmental Quality Technology Program
GPS = Global Positioning System
JPG = Jefferson Proving Ground
OE = Ordnance and Explosives
POC = point of contact
QA = quality assurance
QC = quality control
ROC = receiver-operating characteristic
RTK = real time kinematic
RTS = Robotic Total Station
SERDP = Strategic Environmental Research and Development Program
UXO = unexploded ordnance
YPG = U.S. Army Yuma Proving Ground

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